

BLACK AND VEATCH KANSAS CITY MO

NATIONAL DAM SAFETY PROGRAM, RAY COUNTY DAM NUMBER A-1(MO 11084--ETC(U)

MAY 79 P R ZAMAN, E R BURTON, H L CALLAWAN

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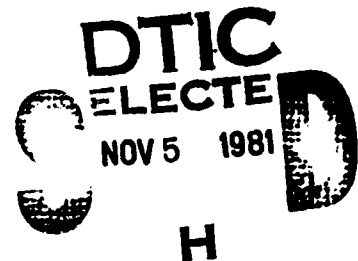
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RAY COUNTY DAM NO. A-1

RAY COUNTY, MISSOURI

MO 11084



**PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION**

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St. Louis District

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MAY 1979

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MISSOURI-KANSAS CITY BASIN

RAY COUNTY DAM NO. A - 1

RAY COUNTY, MISSOURI

MO 11084

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY INSPECTION



**United States Army
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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

MAY 1979



DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Ray County Dam No. A-1, Mo. ID No. 11084
Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Ray County Dam No. A-1. It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY:

SIGNAL

Chief, Engineering Division

25 SEP 1979

Date

APPROVED BY:

SIGNED

Colonel, CE, District Engineer

25 SEP 1979

Date

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RAY COUNTY DAM NO. A-1

RAY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 11084

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF
ST. LOUIS DISTRICT CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

MAY 1979

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Ray County Dam No. A-1
State Located	Missouri
County Located	Ray County
Stream	Willow Creek
Date of Inspection	1 May 1979

Ray County Dam No. A-1 was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as an intermediate size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten the life and property of approximately four families downstream of the dam and would potentially cause damage to State Highway 210 within the estimated damage zone which extends approximately three miles downstream of the dam. The Richmond, Missouri water treatment plant is also located within the defined damage zone.

Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will not pass the probable maximum flood without overtopping but will pass 60 percent of the probable maximum flood, which is greater than the 100-year flood. The spillway design flood recommended by the guidelines is the probable maximum flood. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Deficiencies visually observed by the inspection team were minor amounts of erosion along cattle paths, and erosion of the discharge channel.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. A detailed report discussing each of these deficiencies is attached.

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Black & Veatch



OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
RAY COUNTY DAM NO. A-1

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Ray County Dam No. A-1 be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The Ray County Dam No. A-1, hereafter referred to in this report as Dam No. A-1, is a recently constructed earthen structure located in south-central Ray County, Missouri on Willow Creek. This structure was designed by the Soil Conservation Service and was constructed under their supervision. The principal purpose for this dam is flood control. Dam No. A-1 is an integral part of the Willow Creek Watershed Plan and is located on property owned by Mr. Robert Vandiver of Camden, Missouri. The dam is 19 feet wide at the crest, 1,100 feet long, and 43 feet high. The dam has an emergency spillway located at the left abutment, and a principal spillway with drawdown capabilities located near the right-center of the structure. The embankment has riprap protection to approximately 3 feet above normal pool (El.730.1) and adequate grass cover over the remainder of the embankment and spillway.

(2) A grass-lined emergency spillway is located at the left abutment. It consists of a grass-lined approach channel and discharge channel. The spillway, approach, and discharge channels have trapezoidal cross-sections. The spillway is separated from the dam structure by a protective berm.

(3) A principal spillway consisting of a drop inlet with trash rack, a 30-inch discharge pipe, and a 16-inch valved low water drawdown pipe has been provided at this dam. The 30-inch pipe discharges into a naturally eroded plunge pool before flowing to the main Willow Creek Channel.

(4) Toe drains, 6-inch perforated pipe, are in place and discharge along either side of the principal spillway discharge pipe.

(5) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in south-central Ray County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle maps for Camden and Lexington West, Missouri in Sections 11 and 12 of T51N, R28W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the intermediate size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Ray County Dam No. A-1 has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial, and commercial facilities, and to important public utilities, main highways, or railroads. For the Dam No. A-1 the estimated flood damage zone extends downstream for approximately three miles. Within the damage zone are four homes, farm buildings, State Highway 210, and one improved road crossing.

e. Ownership. The dam is owned and maintained by the Willow Creek Watershed Subdistrict, P.O.Box 380, Richmond, Missouri 64085. The structure is located on property owned by Mr. Robert Vandiver, Camden, Missouri 64017.

f. Purpose of Dam. The dam forms a 39-acre flood control lake.

g. Design and Construction History. Data relating to the design and construction were made available by the Soil Conservation Service, Columbia, Missouri.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, and evaporation all combine to maintain a relatively stable water surface elevation.

i. Maintenance. The Willow Creek Watershed Subdistrict, P.O. Box 380, Richmond, Missouri 64085 is the group responsible for maintenance at this dam.

1.3 PERTINENT DATA

a. Drainage Area - 3,286 acres (includes the 231 acres of Ray County Dam No. A-27 drainage area).

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled principal spillway.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation 6,900 cfs (top of Dam El. 752.8).

c. Elevation (Feet above m.s.l.).

(1) Top of dam - 752.8 \pm (see Plate 3)

(2) Principal spillway crest - 730.0

(3) Emergency spillway crest - 745.6 \pm

(4) Streambed at toe of dam - 710.0 \pm

(5) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 10,000 feet \pm

(2) Length of normal pool - 5,550 feet \pm

e. Storage (Acre-feet).

(1) Top of dam - 2,900

(2) Emergency spillway crest - 1,300

(3) Principal spillway crest - 230

(4) Design surcharge - 690

f. Reservoir Surface (Acres).

- (1) Top of dam - 210
- (2) Emergency spillway crest - 140
- (3) Principal spillway crest - 39

g. Dam.

- (1) Type - Earth embankment
- (2) Length - 1,100 feet
- (3) Height - 43 feet +
- (4) Top width - 19 feet
- (5) Side slopes - upstream and downstream faces 1.0 V on 2.5 H, (Design).
- (6) Zoning - None.
- (7) Impervious core - None.
- (8) Cutoff - Core trench, earthfill.
- (9) Grout curtain - None.

h. Diversion and Regulating Tunnel - None.

i. Emergency Spillway.

- (1) Type - Broad-crested weir with trapezoidal cross section.
- (2) Bottom width of channel - 120 feet (Design).
- (3) Channel side slopes - 1.0 V on 3.0 H (Design).
- (4) Crest elevation - 745.6 feet m.s.l.
- (5) Gates - None.
- (6) Upstream channel - Not applicable.
- (7) Downstream channel - Grass-lined, bermed channel and pasture near the toe of the downstream embankment slope.

j. Principal Spillway.

- (1) Type - Concrete box drop inlet
- (2) Crest elevation - 730.0
- (3) Length of Weir - 2 at 7.5 feet each
- (4) Gates - None.
- (5) Upstream channel - None.
- (6) Discharge pipe - 30-inch diameter reinforced concrete pipe.
- (7) Downstream channel - Open channel comprised of limestone, clays, and silt.

k. Regulating Outlets - A 16-inch diameter rising stem slide gate controls discharge through a 16-inch diameter reinforced concrete pipe (Inv. El. 721.0). The gate is located within the drop inlet. Discharge through the gate proceeds into the base of the drop inlet, then out the 30-inch diameter reinforced concrete pipe beneath the embankment.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data were available in the form of construction logs "As Built" drawings, site geology and soils reports, and the "Willow Creek Watershed -Work Plan."

2.2 CONSTRUCTION

The dam was constructed in 1974 by Kranz Construction Company, 1800 Blue Ridge Blvd., Kansas City, Missouri. Construction log indicated that the core trench had been overexcavated and backfilled with compacted clay material.

2.3 OPERATION

The maximum recorded loading on the dam is unknown.

2.4 GEOLOGY

Dam No. A-1 is located across a broad shallow valley formed in modified loess. The geology of the site consists of the Wabash or Marshall Silt Loam soil series overlying glacial till or shale bedrock of the Marmaton Group of Pennsylvanian System. The Wabash soil series is an alluvial soil developed along the drainage course and derived from material eroded from the surrounding slopes. For engineering purposes, it can be classified as a silt (ML) or silty clay (CL). The Marshall Silt Loam Soil series consists of modified loess and is classified for engineering purposes as a silt (ML) or silty clay (CL).

The foundation and abutments of the dam consist of silty clay (CL) soil derived from loess and Kansas glacial till overlying shale bedrock as shown on the design drawings for the dam. The Kansan Till contains pockets of silty and clayey sand (SC-SM). The bedrock contact is irregular and varies in depth below the original grade from 30 feet to 49 feet to 15 feet from the left to right abutments.

The downstream channel is formed in modified loess and glacial till. No outcrops of bedrock were observed in the channel.

2.5 EVALUATION

a. Availability. Engineering data were obtained as noted in Section 2.1.

b. Adequacy. Engineering data were available from which to make an assessment of the design, construction, and operation. Seismic

stability analysis were performed using available data as noted in Section 6. Seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage analyses should be performed for appropriate loading conditions and made a matter of record.

c. Validity. The available engineering data on the design, construction, and operation were determined to be valid.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Dam No. A-1 was made on 1 May 1979. The inspection team included professional engineers with experience in dam design and construction, hydrology - hydraulic engineering, and geotechnical engineering. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed that the dam is in generally good condition with minor seepage observed trickling from the twin, 6-inch asbestos-cement drain pipes. The flow of water was less than 1 gpm and was clear. The left pipe was noted to have slightly more drainage than the right one. Deficiencies noted during the inspection are as follows:

The dam is located within a fenced pasture and the owner has allowed grazing to take place. Because of this, cattle paths and some areas of overgrazing on the embankment slopes have developed. Some minor erosion has occurred in areas of overgrazing and along the more well defined paths.

A 1-inch plastic waterpipe has been constructed from the lake to a stock watering tank located downstream from the toe of the dam. Some erosion has taken place along the pipe trench. The owner was aware of this problem and mentioned his intention to repair the erosion damage along the pipe trench.

The riprap and grass slope protection on the upstream face are in good condition and appear adequate.

A vehicular path was observed on the dam's crest. Two small animal burrows were found on the downstream face of the embankment.

No evidence of overtopping was observed. Mr. Vandiver stated that to his knowledge the structure has not been overtopped.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. A grass-lined emergency spillway which was constructed near the left abutment appears in good condition. The emergency spillway will act as a broad-crested weir. The emergency spillway approach and discharge channels are grass-lined. They both appear to be in good condition, and the berm protecting the main dam structure is intact. Minor erosion was observed on the left spillway side slope.

The principal spillway consisting of a drop inlet with trash rack appears to be in good condition.

The slide gate within the drop inlet was open approximately 4 inches at the time of inspection. The gate was in good operating condition at the time of inspection.

d. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir.

e. Downstream Channel. Open channel comprised of loess and glacial till soils. The banks of the downstream channel are covered with brush and large trees.

3.2 EVALUATION

The greater flow observed coming from the left drainage outlet as compared with the right drainage outlet may be attributed to the fact that the left drain has a length of 221 feet, whereas the right drain has only 65 feet of perforated pipe as shown on the as-built drawings.

During the inspection there were observed four minor deficiencies which warrant attention. None of these deficiencies should be considered in an emergency category, although, in order to continue to maintain this dam in good to excellent condition they should be rectified.

a. The erosion/settlement of the backfill over the waterline, installed after the construction of the dam, is perhaps the most severe deficiency. If left in the present state, it will in all likelihood continue to deteriorate. Mr. Vandiver, the owner, is aware of this deficiency and reported his intention to place additional backfill over the pipe.

b. Heavy grazing of the dam by cattle has caused some paths to be developed and some localized areas to be overgrazed. Minor areas of erosion have developed as a result of this practice. The dam reportedly has been fertilized to aid in the growth of the cover grass. The potential for increased erosion exists along cattle paths and overgrazed areas. Attention should be given to this possible problem area.

c. The crest has been used as a vehicle crossing and as such two paths have been formed. The paths are void of grass cover and are potential starting points for erosion. Careful monitoring of this condition is warranted.

d. Two small animal burrows were located on the downstream slope. Animal burrows can ultimately jeopardize the safety of an earthen structure if allowed to increase in number. Therefore, continual monitoring

is recommended at this time. In the event additional burrows are observed, a program designed to control burrowing animals should be implemented and corrective action taken for repairing damages.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, capacity of the uncontrolled principal spillway, and the operation of the 16-inch gate.

4.2 MAINTENANCE OF DAM

Under terms of the Soil Conservation Service Watershed program for Willow Creek, Ray County, Missouri, maintenance for Dam No. A-1 is the responsibility of the Willow Creek Watershed Subdistrict, Richmond, Missouri.

Maintenance performed was unknown. It was reported by the owner that he fertilizes the grass cover and allows livestock to graze as a controlling measure for burrowing animals.

4.3 MAINTENANCE OF OPERATING FACILITIES

Maintenance performed was unknown.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

No warning system for this dam exists.

4.5 EVALUATION

The existing maintenance program appears to be adequate for a structure of this type. Minor corrective measures as suggested elsewhere in this report should be implemented to keep this dam in its visibly good condition.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Limited design data pertaining to hydrology and hydraulics were available. Independent calculations were, however, performed for the report in accordance with the referenced guidelines.

b. Experience Data. The drainage area and lake surface area are developed from USGS Lexington West, Rayville, and Camden Quadrangle Maps. The spillway and dam layouts are from surveys made during the inspection and available design documents.

c. Visual Observations.

(1) The emergency and principal spillways are in good condition. Discharge channels for both spillways are also in good condition.

(2) Facilities are available which could serve to draw down the pool. A 16-inch diameter reinforced concrete pipe (Inv. El. 720.0) with gate valve located at the upstream portion of the drop inlet may be used to draw down the pool. The valve was operable at the time of inspection.

(3) An emergency spillway with a grass-lined discharge channel is located near the left abutment. Discharges from this appurtenance are unlikely to endanger the integrity of this dam. The dam is protected from emergency discharges through the spillway and channel by a grass-covered berm. Discharges reach Willow Creek at an appreciable distance downstream from the dam and therefore should not pose any threat to the structure.

(4) A principal spillway with discharge pipe is located at center-right of the dam. This appurtenance should not endanger the integrity of this dam.

d. Overtopping Potential. The emergency and principal spillways discharging simultaneously will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillways will pass 60 percent of the probable maximum flood and the 100-year flood without overtopping the dam. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of intermediate size should pass 100 percent of the probable maximum flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 4,700 cfs of the total discharge from the

reservoir of 14,000 cfs. The estimated duration of overtopping is 4.5 hours with a maximum height of 1.2 feet. Failure of upstream water impoundments shown on the USGS maps would have a significant impact on the hydrologic and hydraulic analyses.

It should be noted that when the total drainage area contributing to Dam No. A-1 is subjected to the prescribed Standard Project Storm five days in advance of a Probable Maximum Storm, Dam No. A-27 is overtopped. During the time interval between applying the standard project storm and the Probable Maximum Storm, the pool level for Dam No. A-1 does not return to the principal spillway crest. In accordance with established procedures, the Probable Maximum Storm was routed through the reservoir starting at the water surface elevation resulting from the previously applied Standard Project Storm.

There was no evidence observed during the inspection which would indicate that this structure has been overtopped. The owner stated that to his knowledge the dam has not been overtopped. Soils typical of this structure's surfaces are erodible. Should the embankment be subjected to prolonged overtopping it is believed that erosion would occur and could lead to failure.

The downstream face of Ray County Dam No. A-27 located upstream from Dam No. A-1 is inundated to within 8 to 10 feet of top of dam when subjecting Dam No. A-1 to the probable maximum flood.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately three miles downstream of the dam. There are four homes, farm buildings, State Highway 210 downstream of the dam which could be severely damaged and lives could be lost should failure of the dam occur. A water treatment plant is located about two miles downstream of this structure which could conceivably be damaged in the event of a dam failure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. Design data relating to the structural stability of the dam were available from the United States Department of Agriculture, Soil Conservation Service, Soil Mechanics Laboratory SUBJECT: ENG 22-5, Missouri WF-08, Willow Creek, Site A-1 (Ray County), dated June 15, 1972.

"As-Built" construction drawings, dated August 4, 1975 were available from the Soil Conservation Service.

As reported in the SCS data, samples for testing were obtained from borings located within the original site area (located 800 feet downstream) and the site upon which Dam No. A-1 was constructed. Soil properties were determined by correlating samples from both sites. Eight jar samples, four small bag samples, and six undisturbed samples were submitted to the laboratory to represent the flood plain materials. Two large jar samples from the emergency spillway and three large bag samples from the upstream borrow area were submitted to represent available fill material.

Laboratory tests performed for the dam design include:

(1) Foundation Area.

- a) Atterberg Limits
- b) Sieve Analysis
- c) Dispersion test
- d) Dry Unit Weight
- e) One Dimensional Consolidation Test
- f) Permeability
- g) Triaxial Shear Test (CU)
- h) Direct Shear

(2) Embankment Materials.

- a) Atterberg Limit
- b) Sieve Analysis
- c) Dispersion Test
- d) Standard Proctor Test
- e) Triaxial Shear Test (CU)

(3) Stability Loading Conditions.

Stability analyses performed by the SCS for the dam design included consideration of two loading conditions:

- a) Steady Seepage
- b) Full Drawdown

(4) Stability Analysis.

a) Steady Seepage. Soil properties used for the SCS evaluation were obtained from laboratory tests conducted on samples taken from the general site area. The angle of internal friction and cohesion for both the embankment and foundation materials were obtained from consolidated undrained triaxial shear tests with pore pressure measurements.

Stability analysis procedures used by the SCS include both the Swedish Circle and Bishop Methods on the IBM-360 Computer. Stability determinations were conducted using the prescribed soil parameters and side slopes as indicated on the construction drawings. A minimum factor of safety of 1.56 was obtained for the steady seepage loading condition using the Swedish Circle Method of Analysis.

b) Full Drawdown. The full drawdown loading condition was analyzed for the upstream embankment slope. Soil parameters used for this analysis were representative of embankment and foundation materials.

Slope stability for the full drawdown condition was analyzed using the Swedish Circle and Bishop Method on the IBM-360 computer. The minimum factor of safety reported for the full drawdown loading condition was found to be 1.46 utilizing the Swedish Method of Analysis.

(5) Evaluation. The available stability analyses performed by the SCS included the factor of safety for steady seepage and full drawdown loading conditions.

The results of the stability analysis for the steady seepage loading condition indicated factors of safety between 1.61 and 1.56 for the Bishop and Swedish Methods respectively. The stability analysis for the full drawdown loading condition reported factors of safety between 1.48 and 1.46 for the Bishop and Swedish Methods respectively. The conditions included in the full drawdown stability analysis are more critical than the potential condition existing at this dam because there are no operating or physical provisions for rapidly lowering the reservoir level. These factors of safety are acceptable and within the suggested values of Appendix D of the guidelines. Consolidated, undrained triaxial shear strength properties were used for both the steady seepage and full drawdown conditions analyzed.

Stability analyses for the partial pool and earthquake loading conditions were not available. The conditions, assumptions, and strength parameters for the full drawdown and steady seepage stability analyses represent a more critical stability condition than for partial pool. The factors of safety determined for the steady seepage and full drawdown loading conditions are about equal to or greater than the suggested factor of safety for the partial pool loading condition.

Stability analyses for the earthquake loading conditions were not available. The design report indicated that the dam is located within an earthquake design Class 1 area in accordance with the "Guide to Earthquake Considerations in Soil Conservation Service Dams in the Midwest Region." In accordance with the guidelines, the dam is located within Seismic Zone 1 with a designated seismic coefficient of 0.025 to be used in the conventional equivalent static force method of analysis.

Seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. The dam includes a sand-gravel filter constructed beneath the downstream embankment section. The filter section is 6 feet 6 inches deep by 3 feet 6 inches wide and is constructed beneath the access trench excavation. A 6-inch diameter perforated pipe is installed in the filter material, and the filter material is drained beyond the downstream toe. The underseepage control system appears adequate for this facility.

c. Operating Records. No operational records were available for review by the inspection team.

d. Post Construction Changes. No known post construction changes.

e. Seismic Stability. Stability analyses were performed by Black & Veatch using a seismic coefficient of 0.05 (seismic design coefficient according to the Department of Army, Corps of Engineers, EM 1110-2-1902) applied to the critical failure arc for each of the full drawdown and steady seepage analyses. The calculated factors of safety were greater than 1.0. The seismic stability of this dam satisfies the requirements

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several items noted during the visual inspection by the inspection team which should be monitored or controlled are erosion/settlement of backfill material over the waterline installed after dam construction, overgrazing and extensiveness of cattle path development, animal burrows and erosion/rutting of dam crest. Seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. The conclusions in this report are based on performance history, visual conditions, and the available engineering design data. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. It is the opinion of the inspection team that a program should be developed to implement remedial measures recommended in paragraph 7.2b. If the safety deficiencies listed in paragraph 7.1a are not corrected, erosion will continue and lead to a potential of failure. The items recommended in paragraph 7.2a should be analyzed on a priority basis by the owners of this dam.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam or identify any serious dangers that would require a Phase II investigation.

e. Seismic Stability. This dam is located in Seismic Zone 1. The dam is considered to be adequately designed and constructed to withstand an earthquake normally expected for the area.

7.2 REMEDIAL MEASURES

a. Alternatives. The principal and emergency spillways, acting together, have the capacity to pass 60 percent of the probable maximum flood without overtopping the dam. In order to pass 100 percent of the probable maximum flood as required by the Recommended Guidelines, the spillway sizes and/or height of dam would need to be increased.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended:

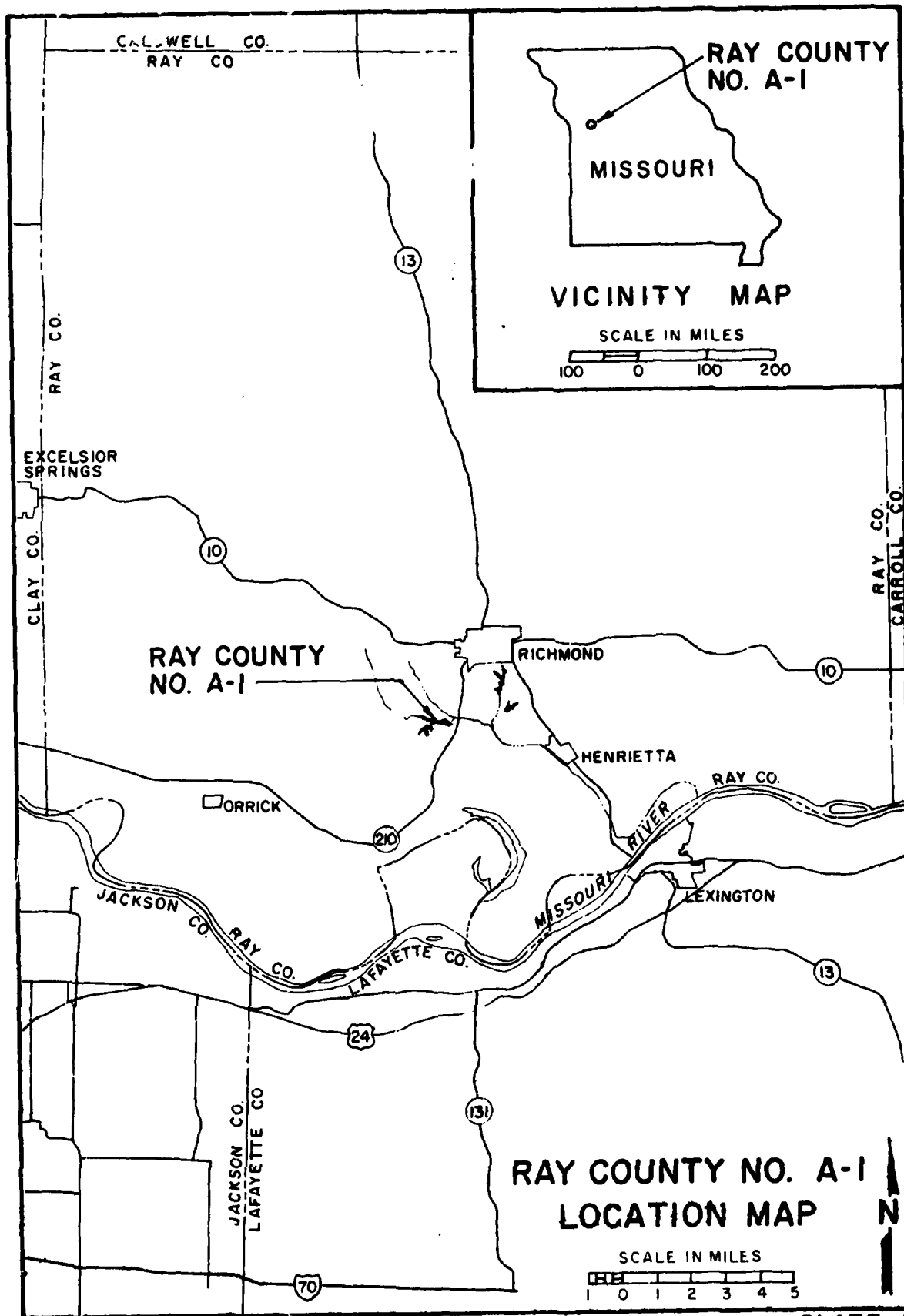
(1) Measures should be implemented to maintain control of burrowing animals. An engineer experienced in earth dam maintenance should be consulted to provide guidance in the repair of existing animal burrows.

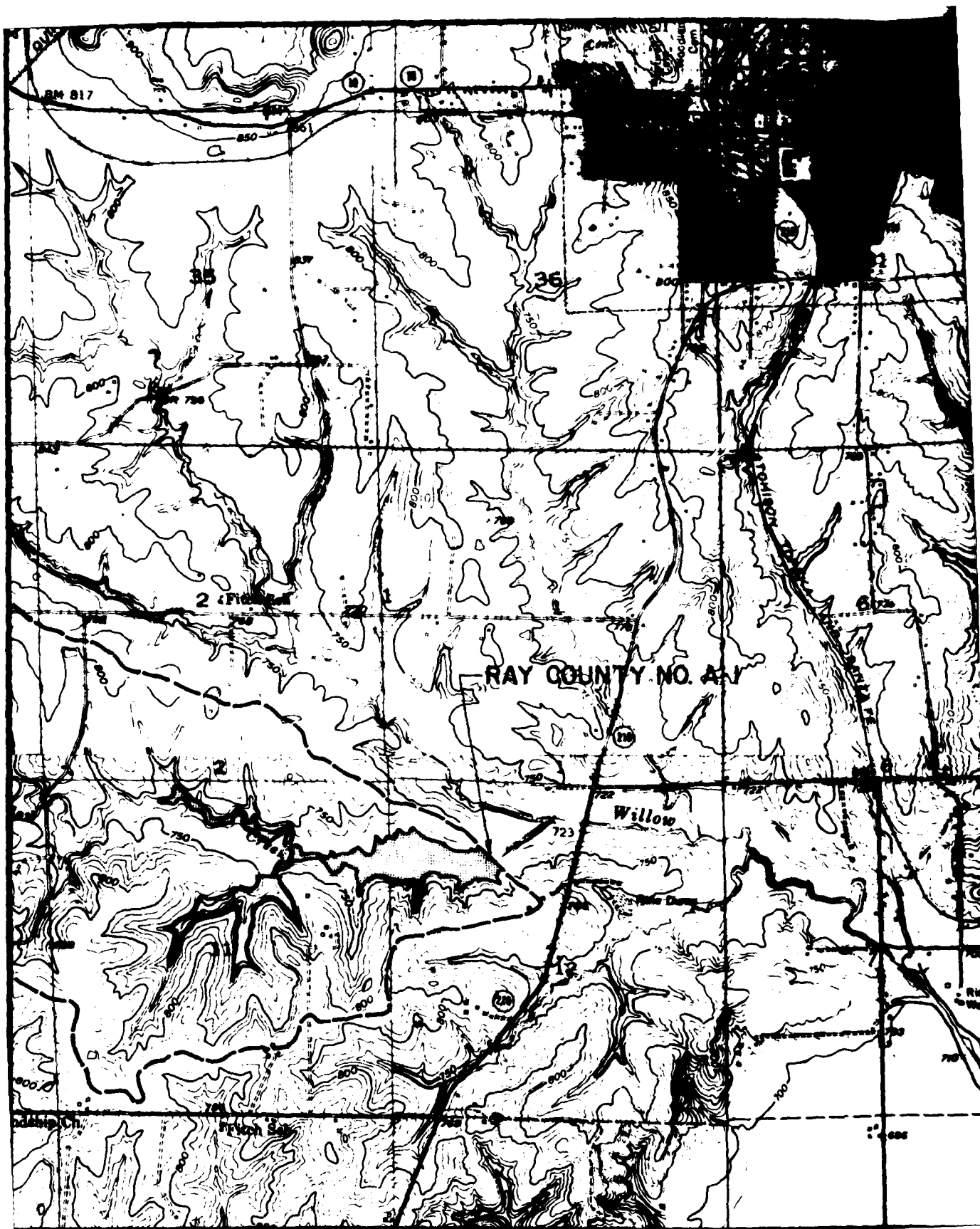
(2) Cattle grazing should be controlled on this structure. Monitoring of overgrazing and path development should be initiated. In the event erosion becomes extensive in those areas of grazing, etc., the erosion should be repaired and cattle be kept off the dam.

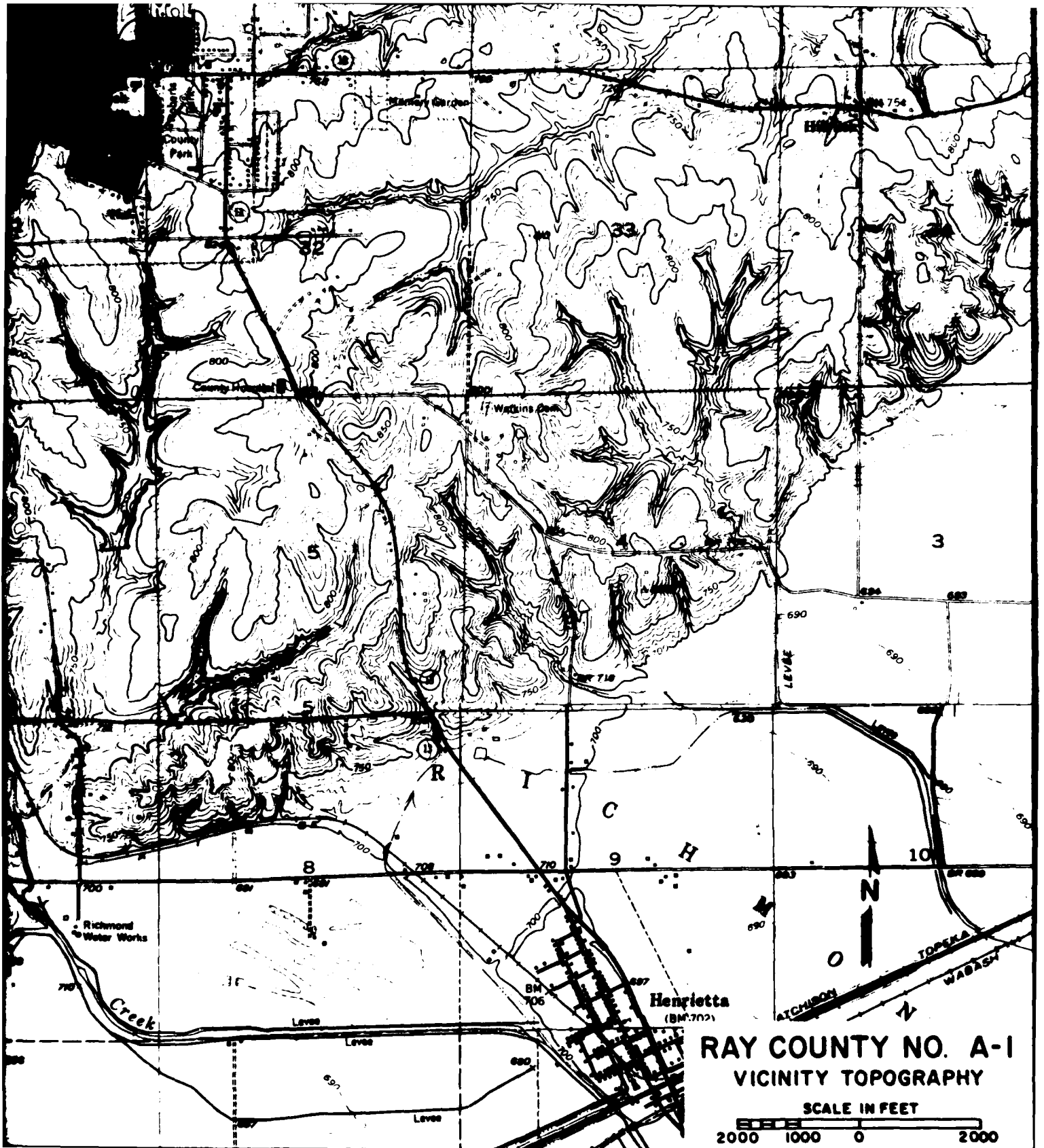
(3) Controlled seepage should be monitored on a regular interval and records maintained documenting discharge and visible condition of the seepage discharged through the drain pipes. In the event quality or quantity conditions change, an engineer experienced in earth dam design should be consulted.

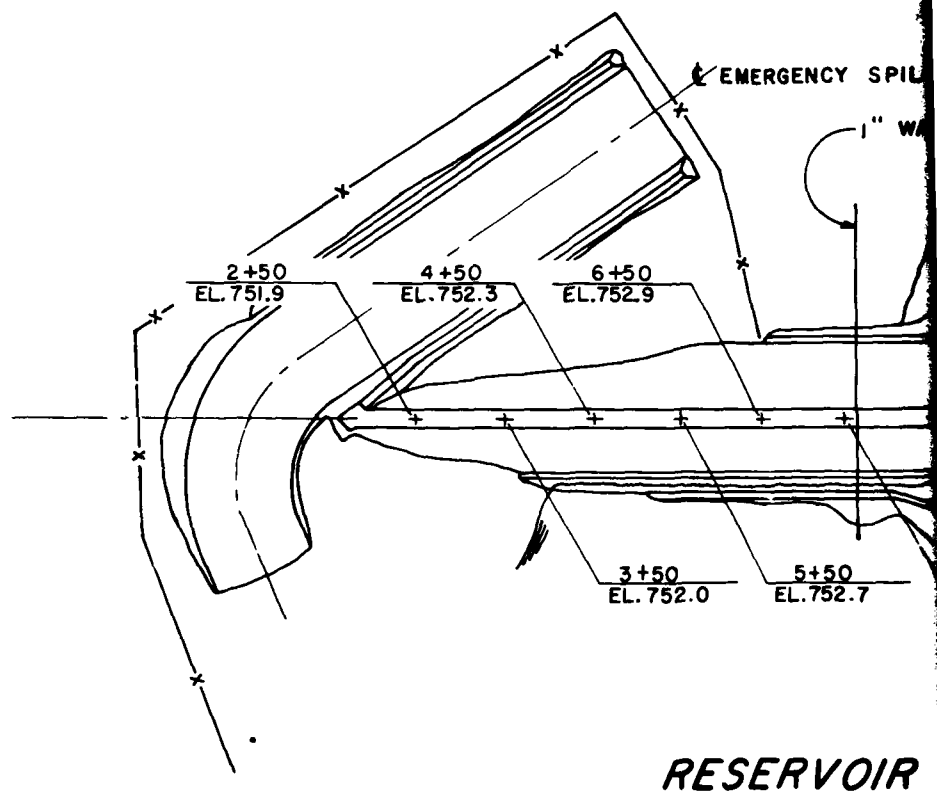
(4) Seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage analyses should be performed for appropriate loading conditions and made a matter of record.

(5) A detailed inspection of the dam should be made periodically by an engineer experienced in design and construction of dams. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increases.



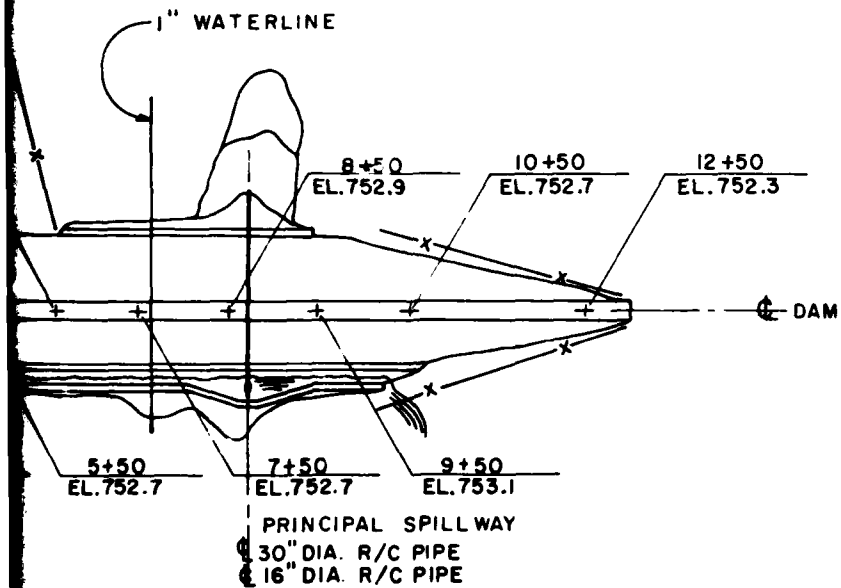






DATA SOURCE: PLAN VIEW FROM DESIGN DOCUMENTS,
STATIONING AND ELEVATIONS FROM
FIELD SURVEY.

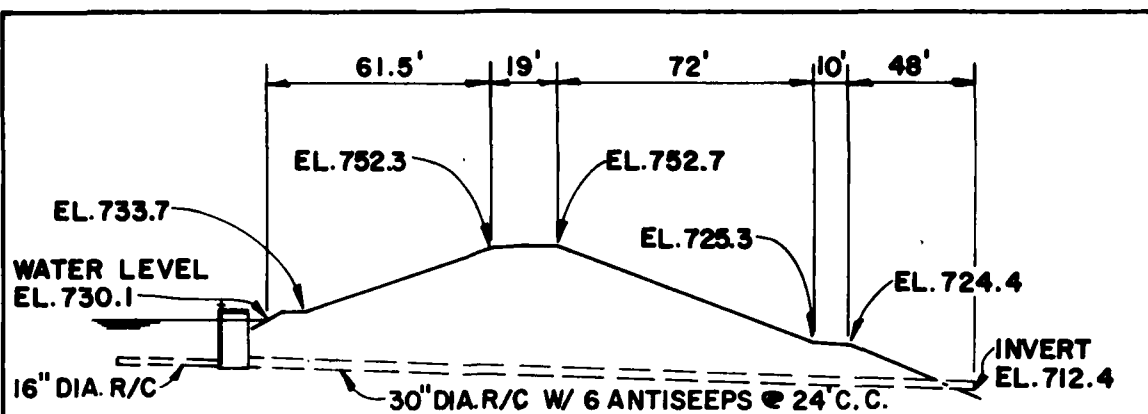
EMERGENCY SPILLWAY



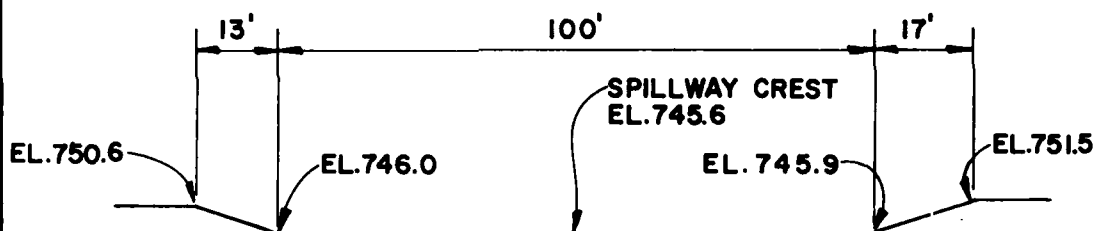
SERVOIR A-1

RAY COUNTY DAM NO. A-1
PLAN

PLATE 3



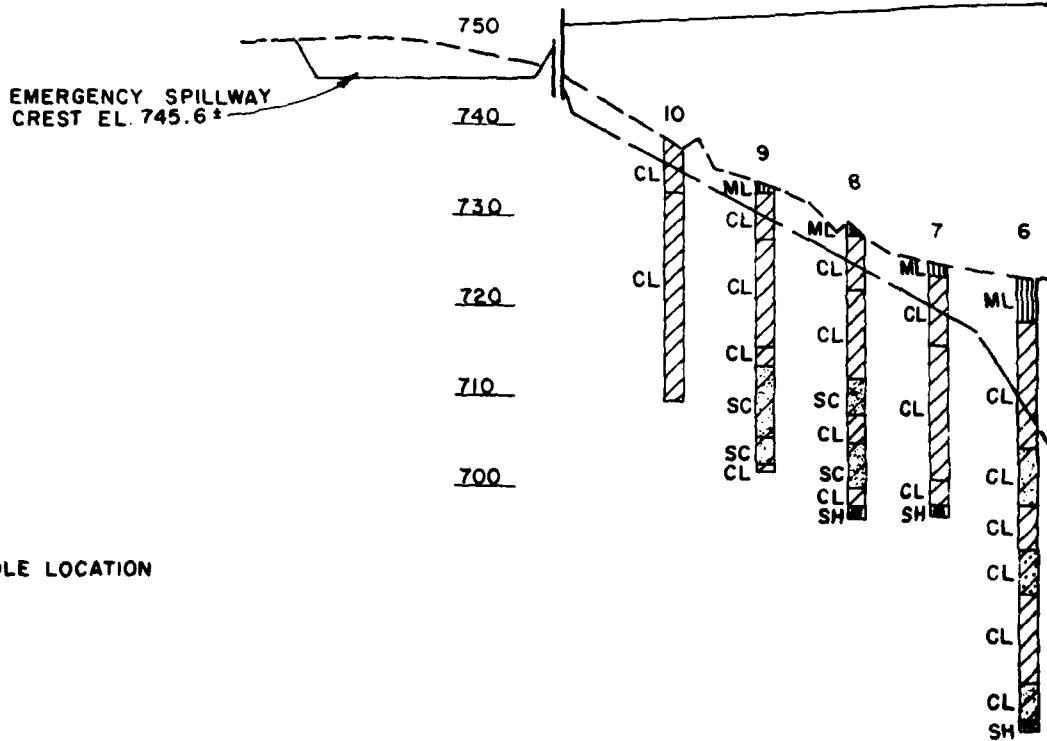
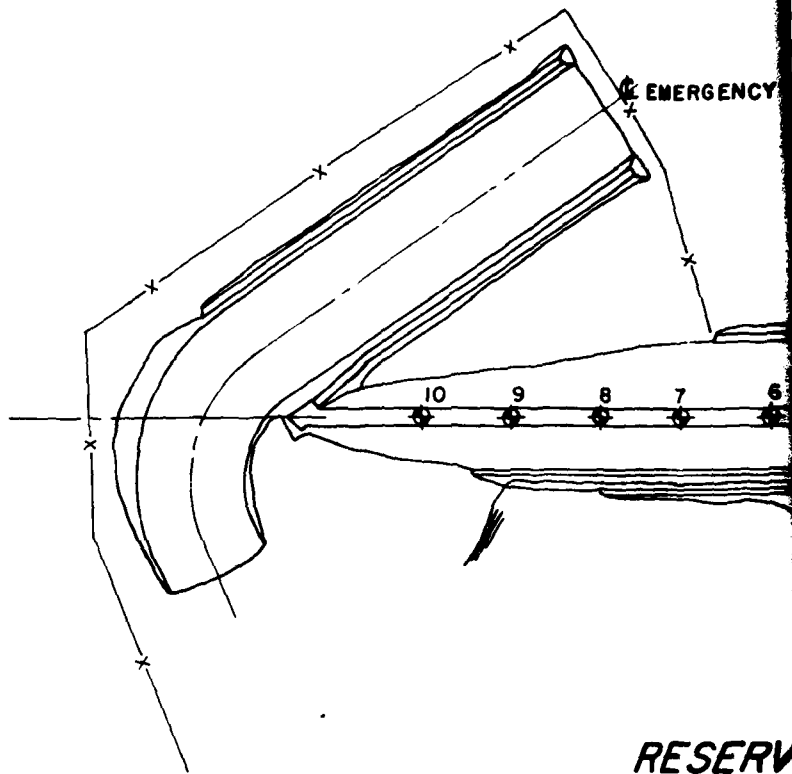
SECTION TAKEN AT APPROX. 8+70
TYPICAL



SECTION TAKEN LOOKING DOWNSTREAM
EMERGENCY SPILLWAY

DATA SOURCE: FIELD SURVEY

RAY COUNTY DAM NO. A-1
TYPICAL & SPILLWAY SECTIONS

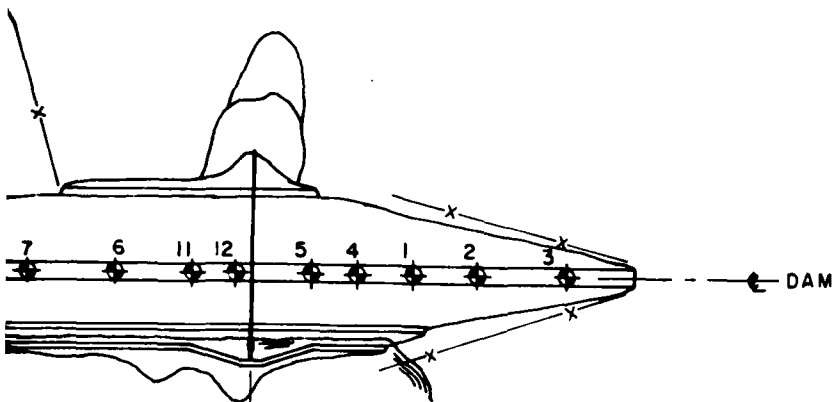


LEGEND



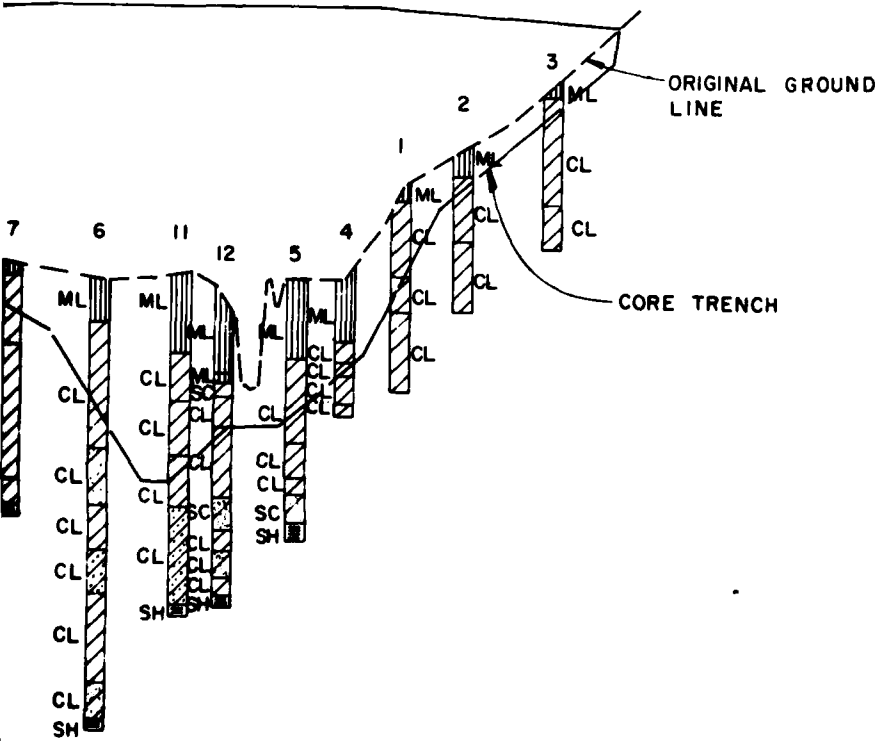
BORING HOLE LOCATION

EMERGENCY SPILLWAY

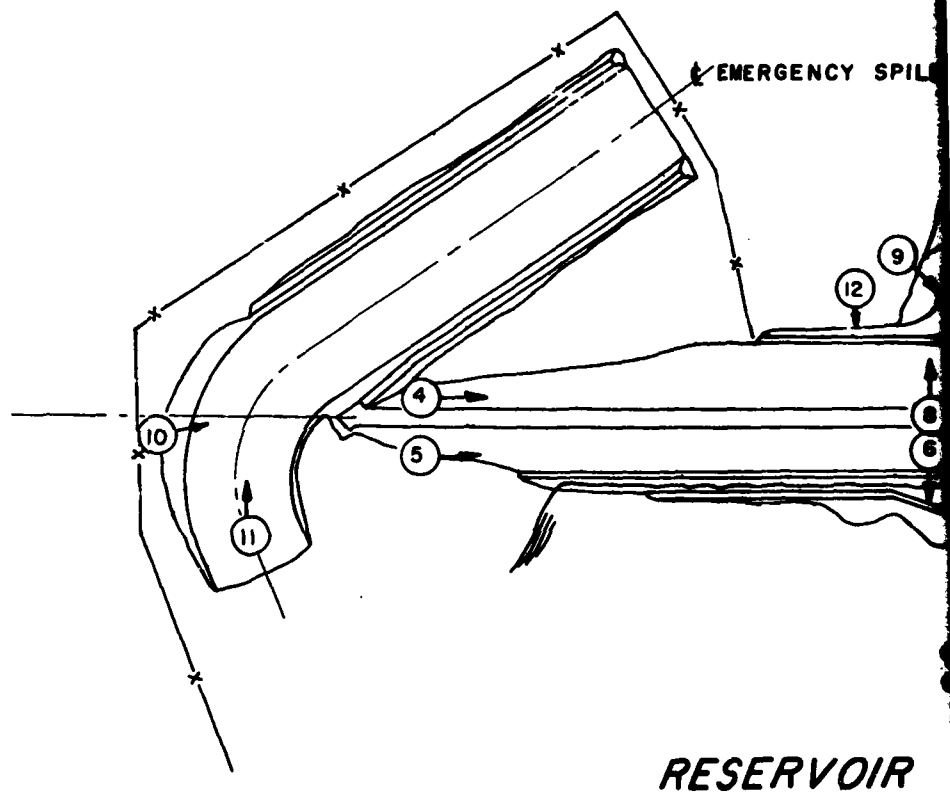


PRINCIPAL SPILLWAY
 30" DIA. R/C PIPE
 16" DIA. R/C PIPE

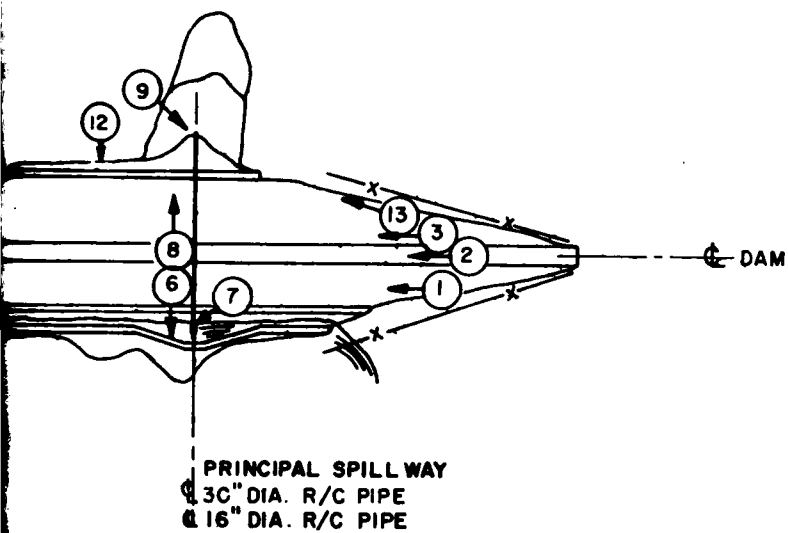
RESERVOIR A-1



RAY COUNTY DAM NO. A-1
 BORING PLAN



EMERGENCY SPILLWAY



RESERVOIR A-1



RAY COUNTY DAM NO. A-1
PHOTO INDEX

PLATE 6



PHOTO 1: UPSTREAM FACE OF DAM



PHOTO 2: CREST OF DAM



PHOTO 3: DOWNSTREAM FACE OF DAM (LOOKING FROM RIGHT ABUTMENT)



PHOTO 4: DOWNSTREAM FACE OF DAM (LOOKING FROM LEFT ABUTMENT)



PHOTO 5: RIPRAP ON UPSTREAM FACE

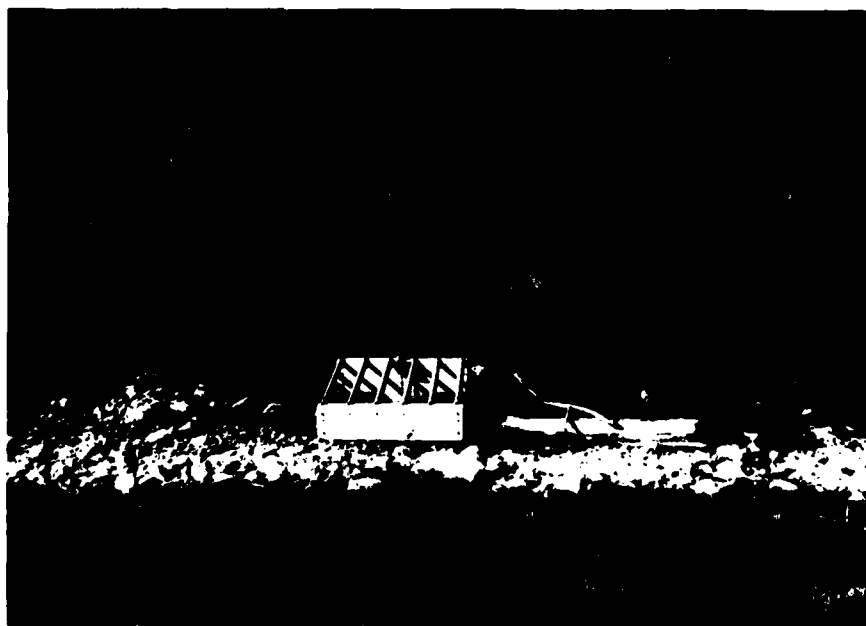


PHOTO 6: PRINCIPAL SPILLWAY

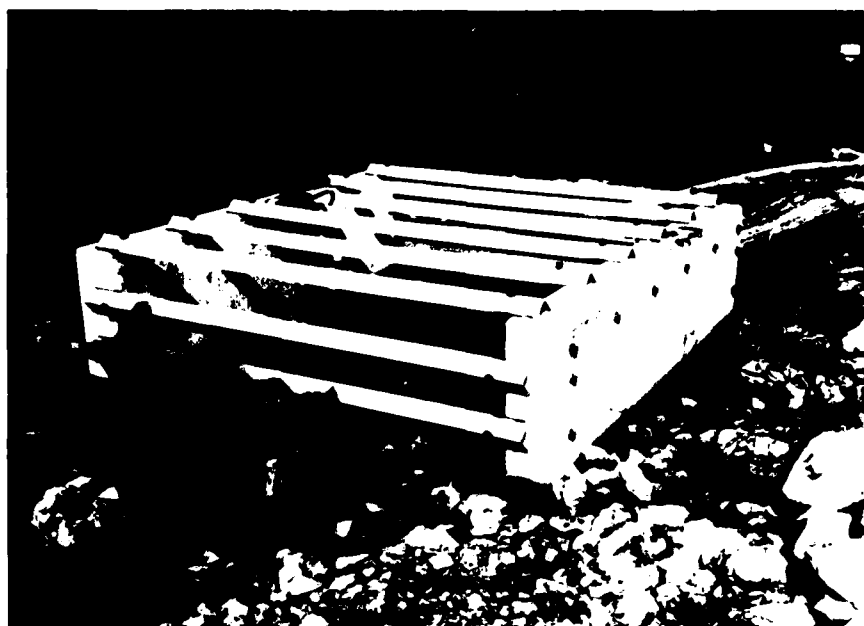


PHOTO 7: PRINCIPAL SPILLWAY



PHOTO 8: TOE DRAINS, DISCHARGE CULVERT, AND DOWNSTREAM CHANNEL

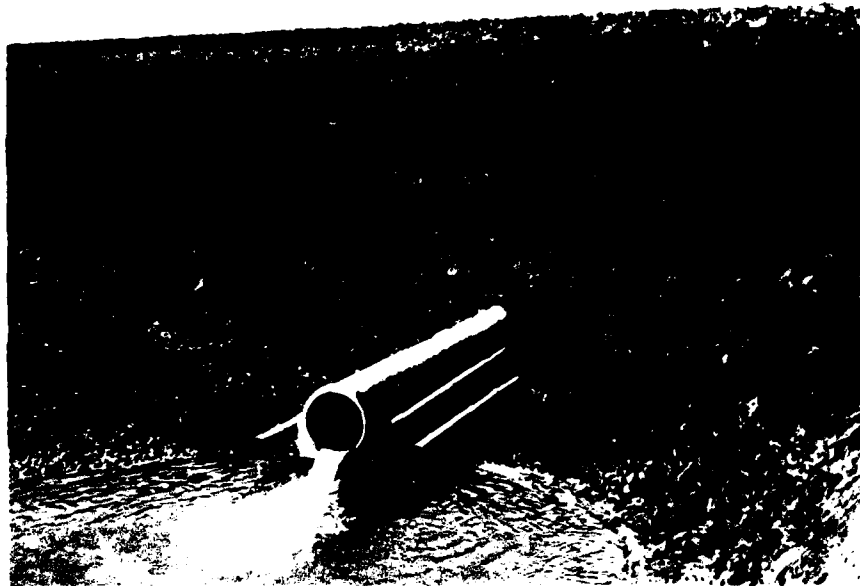


PHOTO 9: TOE DRAINS AND DISCHARGE CULVERT



PHOTO 10: EMERGENCY SPILLWAY AND CREST OF DAM
(LOOKING FROM LEFT ABUTMENT)



PHOTO 11: EMERGENCY SPILLWAY (LOOKING DOWNSTREAM)

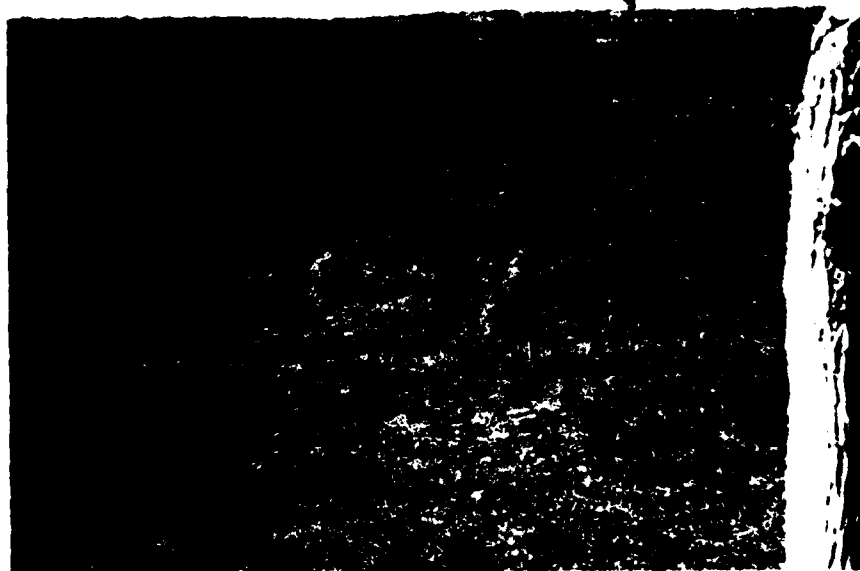


PHOTO 12: EROSION OF PIPE TRENCH BACKFILL ON DOWNSTREAM FACE



PHOTO 13: EROSION NEAR DOWNSTREAM TOE (RIGHT ABUTMENT AREA)

APPENDIX A
HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1 (1) were used to develop the inflow hydrographs, and hydrologic inputs are as follows:

a. Forty-eight hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

200 square mile, 24 hour rainfall inches	- 24.5
10 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 101%
10 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 120%
10 square mile, 24 hour percent of 24 hour 200 square mile, rainfall	- 130%
10 square mile, 48 hour percent of 24 hour 200 square mile, rainfall	- 140%

b. Drainage area = 3,286 acres (includes 231 acres of Ray County Dam No. A-27).

c. Time of concentration:

$$T_c = (1.67) L$$

$$L = \frac{\ell^{0.8} (S+1)^{0.7}}{1,900Y^{0.5}}$$

L = lag in hours

ℓ = hydraulic length of watershed in feet

$$S = \frac{1,000}{CN} - 10 \text{ (where CN is the retardance factor and is equivalent to the runoff curve number)}$$

Y = average watershed land slope in percent

$$T_c = 4.85 \text{ hours (for Dam No. A-1 drainage area not including the Ray County Dam No. A-27 drainage area)}$$

$$= 0.48 \text{ hours (for Ray County Dam No. A-27 drainage area).}$$

(2)

1

d. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 86 and antecedent moisture condition III. The hydrologic soil groups in the basin were B, C, and D.

e. The soil association in this watershed is mainly Marshall Silt Loam Series. (3)

2. Principal spillway release rates are based on the weir and pipe flow equations.

Weir equation:

$$Q = CLH^{1.5} \quad (C = \text{varies from } 2.75 \text{ to } 3.32, L = 15.0 \text{ feet, } H \text{ is the head on weir}).$$

Pipe-flow equation:

$$Q = Ca(2gh)^{0.5} \quad (C = 0.56, a = 4.91 \text{ ft}^2, g = 32.2 \text{ ft/sec}^2, h = \text{difference in reservoir surface elevation and downstream culvert discharge outlet}).$$

Emergency spillway releases are based upon calculations of critical depths of flow at the crest. Reservoir elevations corresponding to given spillway release rates were calculated by adding to the critical depth, d_c ; the velocity head, $v^2/2g$; and the friction head, h_f . (4)

Discharge rates over the top of the dam are also based on the weir equation:

$$Q = CLH^{1.5} \quad (C = 3.1, L = 1,100 \text{ feet}).$$

3. The elevation-storage relationship above normal pool elevation was constructed by planimetering the area enclosed within each contour above normal pool. Storage at various elevations was computed utilizing the conic method for computation of reservoir volume provided in HEC-1(1).

4. The inflow hydrograph for Ray Co. Dam No. A-27 is routed through the reservoir and principal and emergency spillways of Dam No. A-27. The discharge hydrograph for Dam No. A-27 is combined with the inflow hydrograph generated in the remainder of the watershed for Dam No. A-1. This combined hydrograph is routed through the reservoir and spillways for Dam No. A-1. Floods are routed through the reservoirs using HEC-1, modified Puls.

5. Routing of the 48-hour probable maximum flood through Dam No. A-1 began with an initial storage in the reservoir of 356 acre-feet and a

surcharge of 6.5 feet on the principal spillway due to the reservoir surface elevation not returning to principal spillway crest resulting from applying a standard project flood in the preceding five days.

BIBLIOGRAPHY

- (1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.
- (2) U.S. Department of Agriculture, Soil Conservation Service, SCS National Engineering Handbook, Section 4, Hydrology, August, 1975.
- (3) Soil and Water Conservation District of Ray County, Watershed Work Plan Willow Creek Watershed, Ray County, Missouri, November 1, 1965.
- (4) U.S. Department of Agriculture, Soil Conservation Service, Engineering Division, Hydraulics of Broad-Crested Spillways, Technical Release No. 39, Design Unit, May, 1968.

[illegible]

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO	RATIOS APPLIED TO FLOWS				
					1	2	3	4	5
					.50	.55	.60	.65	1.00
HYDROGRAPH AT	1	.76 (.93)	1	1286. (36.36)	1417. (40.00)	1541. (43.64)	1669. (47.27)	2568. (72.73)	
	2	.76 (.93)	1	795. (22.51)	989. (28.00)	1111. (31.45)	1230. (34.82)	2042. (57.83)	
ROUTED TO	3	4.77 (12.35)	1	6746. (190.97)	7419. (210.67)	8093. (229.17)	8767. (248.26)	13488. (381.94)	
	4	5.13 (13.29)	1	7066. (200.02)	7746. (219.34)	8427. (238.64)	9109. (257.94)	13981. (395.89)	
ROUTED TO	5	5.13 (13.29)	1	5169. (146.38)	5836. (168.08)	6641. (188.06)	7428. (216.01)	13739. (389.04)	

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1									
ELEVATION		INITIAL VALUE		SPILLWAY CREST		TOP OF DAM			
STORAGE		735.49		730.00		752.80			
OUTFLOW		285.		0.		2377.			
		107.		0.		6884.			
RATIO OF PMF	MAXIMUM RESERVOIR W.S.-ELEV	MAXIMUM DEPTH OVER DAM		MAXIMUM STORAGE AC-FT		MAXIMUM OUTFLOW CFS		DURATION OVER TOP HOURS	
								TIME OF MAX OUTFLOW HOURS	
.50	751.64	0.00		2302.		5100.		0.00	
.55	752.14	0.00		2402.		5936.		44.50	
.60	752.63	0.00		2502.		6641.		44.00	
.65	753.03	.23		2586.		7628.		44.00	
1.00	754.04	1.24		2806.		13739.		4.50	
								43.00	
								0.00	
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